

UNITED STATES PATENT APPLICATION

of

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for

**ARCHITECTURAL LAMINATE PANEL WITH EMBEDDED
COMPRESSIBLE OBJECTS AND METHODS FOR MAKING THE SAME**

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ARCHITECTURAL LAMINATE PANEL WITH EMBEDDED COMPRESSIBLE OBJECTS AND METHODS FOR MAKING THE SAME

BACKGROUND OF THE INVENTION

1. The Field of the Invention

[0001] This present invention relates generally to decorative laminate products and processes, for use in architectural design.

2. Background and Relevant Art

[0002] Recent architectural designs have focused on decorative laminate panel products, such as glass or laminate products, which can be used as decorative windows, and as partitions in offices and homes. In particular, decorative laminate panels are now particularly popular compared with decorative glass panels since decorative laminate panels can be manufactured to be more resilient, and to have the same appearance as glass but with less cost. Furthermore, decorative laminate products (or “laminate products”, or “laminates”) more readily enable a recent trend in architectural design of embedding decorative objects within the decorative laminate panel product.

[0003] Present laminate products generally used for creating decorative laminate panels comprise polyvinyl chloride, acrylic, poly(methylmethacrylate) or “PMMA”, poly(ethylene-co-cyclohexane 1,4-dimethanol terephthalate) or “PETG”, as well as related polycarbonates. While each of the aforementioned laminates can serve as an appropriate glass substitute, each laminate material varies in physical properties from one material to the next. For example, polycarbonates, PETG, and PMMA are generally received for use in solid sheet form (i.e., extruded). An extruded sheet is generally a solid preformed sheet, such as a solid 4' x 8' PETG sheet (alternatively, 3' x

5' sheet, 5' x 10' sheet, etc.), which ultimately can form a surface of a decorative laminate panel when the panel is in final form. By contrast, acrylic materials used in decorative panels are generally handled in liquid form. The different physical properties ultimately have a result on the manufacturing cost, as well as the ultimate look of the clear product, depending on the application.

[0004] To embed decorative objects inside extruded sheets, two or more extruded sheets are pressed and heated around the decorative objects. The final decorative product therefore typically comprises two viewable surfaces of the final decorative laminate panel inside of which can be viewed the decorative objects. Due, however, to the conventional pressure (e.g., 80-100 psi) used to press and set the decorative laminate panel, extruded decorative laminate panels are suited primarily for embedding flat objects, such as flattened leaves, ferns, cutout designs, fabrics, and so forth. Extruded panels, however, are also suited for embedding fairly rigid three-dimensional materials, such as crushed glass or rocks that can withstand the conventional pressure (80 psi or greater).

[0005] It would be impossible, however, to embed compressible objects (i.e., relatively soft objects, such as objects that would flatten at pressures of 80 psi or greater), such as thatch, willow reed, straw, coffee beans, twigs, bamboo, and so forth having any measurable diameter, in extruded sheets using the pressure of conventional processing methods. In particular, compressible natural objects would not carry their natural appearance in the final decorative laminate panel since they would be flattened under conventional pressure. Furthermore, when the compressible objects are compressed between the extruded sheets, air bubbles can form that are very difficult to remove.

This can result in air bubbles that are easy to see inside the decorative laminate panel, as well as imperfections on the surface of the decorative laminate panel.

[0006] By contrast, acrylic decorative panels do not use pressure that would otherwise crush compressible objects. Furthermore, acrylic panels do not have the same difficulty with air bubbles that would be common with decorative laminate panels made by embedding objects between extruded sheets. For example, liquid acrylic can be cast around flat, rigid, or soft and compressible objects, by pouring the liquid acrylic around the desired objects, and then solidifying the acrylic into a hardened panel. The liquid acrylic generally forces out air as it moves around the object. As such, acrylic panels can include a wider variety of objects embedded inside, whether flat, rigid, or soft and compressible natural objects. In particular, the hardened acrylic panel therefore can be viewed having a wide variety of objects inside that have not been flattened, and hence maintain a three-dimensional shape.

[0007] Unfortunately, acrylic is not an ideal material for creating decorative panels for use in architectural design. For example, acrylic panels are not very resistant to cracking or shattering compared with some decorative laminate panels made from extruded sheet materials, such as extruded PETG sheets. Furthermore, acrylic panels have a fairly high error rate due to the process of casting (pouring and setting), and are thus more inefficient to produce. For these and other reasons, cast acrylic panels are also much more expensive compared with extruded PETG laminate panels.

[0008] Accordingly, an advantage in the art can be realized with decorative laminate panels that combine the benefits of casting materials with the benefits of extruded sheet materials. In particular, an advantage in the art can be realized with decorative laminate panels that have the advantages of being able to embed compressible objects inside the

panel without air bubbles, and without significantly flattening the compressible objects.

Such decorative laminate panels should also have the advantages of resiliency, ease of manufacture, and should be relatively low in cost.

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BRIEF SUMMARY OF THE INVENTION

[0009] The present invention solves one or more of the foregoing problems in the art with processing methods that allow compressible objects to be embedded in extruded laminate materials without flattening the objects, and without significantly trapping air.

In particular, novel processing methods allow compressible objects, such as thatch, willow reed, coffee beans, bamboo, and similar objects to be embedded within opposing, extruded laminate sheets.

[0010] In one exemplary implementation, compressible objects are arranged on a first extruded laminate sheet. The compressible objects are arranged so that one or more passageways between the compressible objects allow air to escape in the forming process. A second extruded laminate sheet is then positioned against the compressible objects so that the compressible objects are set between opposing first and second laminate sheets in a laminate sheet assembly.

[0011] The laminate sheet assembly is ultimately placed in a compression chamber and subjected to a relatively low first pressure of up to approximately 10 psi. Temperature is then elevated to a first elevated temperature, such that the laminate sheets begin to soften. The laminate sheet assembly is then subjected to a relatively higher second pressure of up to approximately 40 psi. The temperature is also then elevated to a second elevated temperature, such that the compressible objects begin to sink into the opposing first and second laminate sheets without significantly flattening. Remaining steps in the process subject the laminate sheet assembly to relatively high pressure of up to approximately 100 psi, and temperature of up to approximately 240 degrees so that the laminate sheet assembly can be pressed into final form. When the laminate sheet

assembly is cooled, a final product is formed that comprises the compressible objects in a relatively uncompressed, or natural, state, relatively free of visibly trapped air.

[0012] Additional features and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by the practice of the invention. The features and advantages of the invention may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims. These and other features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0013] In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. . Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0014] Figure 1A illustrates a plan view of a surface of an exemplary implementation of a final product of the present invention in which thatch reed is embedded in a single image layer;

[0015] Figure 1B illustrates a cross-sectional view of Figure 1A;

[0016] Figure 1C illustrates a plan view of a surface of an exemplary implementation of a final product of the present invention in which coffee beans are embedded in a single image layer;

[0017] Figure 1D illustrates a cross-sectional view of Figure 1C;

[0018] Figure 1E illustrates a plan view of a surface of an exemplary implementation of a final product of the present invention in which thatch reed is embedded between multiple image layers;

[0019] Figure 1F illustrates a cross-sectional view of Figure 1E;

[0020] Figure 2A illustrates a partially exploded, cross-sectional view of a laminate sheet assembly for use in accordance with an implementation of the present invention;

[0021] Figure 2B illustrates an exploded perspective view of a sequence for positioning components of the laminate sheet assembly in Figure 2A in accordance with an exemplary implementation of the present invention;

[0022] Figure 3A illustrates a chart of processing steps and corresponding pressure and temperature ranges for implementing a process for forming a decorative laminate panel product in accordance with an exemplary implementation of the present invention;

[0023] Figure 3B illustrates a sequence of physical changes in a single-layered laminate assembly when the single-layered laminate assembly undergoes inventive process steps as exemplified in Figure 3A; and

[0024] Figure 3C illustrates a sequence of physical changes in a two-layered laminate assembly when the two-layered laminate assembly undergoes inventive process steps as exemplified in Figure 3A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] The present invention extends to both methods and systems that allow compressible objects to be embedded in extruded laminate materials without flattening the objects, and without significantly trapping air. In particular, processing methods as detailed herein allow compressible objects, such as thatch, willow reed, coffee beans, bamboo, and similar objects to be embedded within opposing, extruded laminate sheets.

[0026] As used herein, “compressible objects” refers to three-dimensional objects that substantially deform at pressures up to 80-90 psi. That is, each “compressible” object can be thought of as having a “critical pressure”. For the purposes of this specification and claims, “critical pressure” refers to the pressure at which the structural integrity of the object collapses, such that the object splits, cracks, or otherwise compresses into an unnatural conformation. There are, of course, varying grades of collapse, or compression, for any given compressible object, such that an “unnatural conformation” may mean that an object has compressed to 90% of its thickness in one direction, 75% of its thickness in one direction, and so on. Most generically, therefore, compressible objects will be understood to fill a modicum of three-dimensional space, such as objects that would otherwise appear unnaturally shaped when collapsed a given amount. Furthermore, the term “compressible” is relative to the extruded sheet materials, and related temperatures and pressures. Hence, for extruded PETG materials, compressible objects will be understood as having a critical pressure of up to approximately 92 psi using conventional thermosetting processes.

[0027] Figures 1A-1F provide an overview of exemplary embodiments of final decorative laminate panels 100, 110, and 120 in accordance with aspects of the present invention. In particular, Figure 1A illustrates a surface view of an exemplary

implementation of a final product of the present invention in which thatch reed is embedded between two extruded laminate sheets. As shown, a finalized laminate panel 100 product can comprise a viewable surface 105 and a cross section 107 (see Figure 1B). In addition, as will be detailed herein, the laminate panel depicted in Figure 1A is properly understood to be a single image layer. That is, the single image layer comprises only a single layer of embedded objects 235.

[0028] Since the laminate panel is generally transparent or translucent on both sides (although this is not required), each viewable side of the panel can be properly referred to as the viewable surface 105. By contrast, the cross section 107 (Figure 1B) will be understood for the purposes of this specification and claims to refer to the depth or thickness of the laminate panel 100, which is generally perpendicular to the viewable surface 105. These distinctions between viewing sides and cross sections are consistent for Figures 1C through 1F.

[0029] Generally, the embedded objects 235 will be positioned within the laminate panel 100 so that the objects are interposed between an oriented in a plane that is roughly parallel with the opposing viewable surfaces 105. This is typically true for more elongate objects, such as thatch, willow reed, and so forth; whereas, less elongate objects, such as coffee beans, may align in the plane, or in a rotated position relative to the plane. In any case, a cross section of the embedded objects 235 can also generally be viewed when viewing the cross section 107 of the laminate panel 100. In Figure 1A, the embedded objects 235 are natural elongate materials, such as thatch, bamboo, or willow reed. Furthermore, as shown in Figure 1B, the cross section 107 of the panel 100 shows that the embedded objects 235 in panel 100 are relatively uncompressed

when the panel 100 is in final form. As such, their respective diameters 237 are substantially the same as prior to being embedded in the panel 100.

[0030] Figure 1C illustrates a surface view of an exemplary implementation of a final product of the present invention in which decorative beans, such as coffee beans, are the embedded objects 235 within laminate panel 110. The laminate panel 110 further has a viewable surface 115, and a cross section 107 (see Figure 1D), which further depicts corresponding views of the embedded objects 235. Figure 1C, therefore, shows a single image layer of a different implementation of embedded objects 235 compared with Figure 1A. Furthermore, as shown in Figure 1D, the cross section 117 of the panel 110 shows that the embedded objects 235 in panel 110 are relatively uncompressed. As such, the respective diameters 232 of the embedded objects 235 are substantially the same as prior to being embedded in the panel 110.

[0031] Figure 1E illustrates a surface view of an exemplary implementation of a final product of the present invention in which thatch reed, as in Figure 1A, is embedded in multiple layers of a laminate panel 120. The laminate panel 120 further has a viewable surface 125, and a cross section 127 (see Figure 1F). In particular, Figure 1E is distinguished from Figures 1A through 1D at least for having two or more image layers being bisected by an imaginary plane 130. Because of the multiple image layers, the viewable surface 125 of panel 120 therefore contrasts with the viewable surface 105 of panel 100 by having a greater density of embedded objects 235. Furthermore, the cross section 127 of the panel 120 shows that the embedded objects 235 in panel 120 are relatively uncompressed, and are not split or cracked. As such, their respective diameters 237 are substantially the same as prior to being embedded in the panel 120.

[0032] Figure 2A illustrates an overview of a laminate sheet assembly 200 for use in accordance with an exemplary implementation of the present invention. While Figure 2B illustrates a sequential overview for positioning components of the laminate sheet assembly 200 in Figure 2A, albeit rotated by 90°. As shown, a laminate sheet assembly 200 has a bottom layer 210 that will be used to guide the laminate sheets and embedded objects 235 into a thermosetting press (not shown), such as a stationary press. The process of sending a laminate assembly 200 through a stationary press to form a final product is described in greater detail in U.S. Patent Nos. 6,025,069, 5,998,028, 5,958,539, 5,894,048, and 5,643,666, each of which is incorporated herein.

[0033] In at least one implementation, the bottom layer 210 is a metal plate, such as a steel or aluminum plate having a thickness of approximately 2 mm. Because the metal plate 210 is subject to repeated stresses from continual direct contact with the stationary press platens (not shown), metal plate 210 is typically not a perfectly flat surface. Accordingly, it can be useful to use a soft, albeit heavy duty, next layer which is generally a pressure pad 215 positioned on top of the metal plate 210. The pressure pad 215 can be useful to help equalize the pressure on, and temperature of, the remaining layers, thereby helping form a highly uniform surface of the decorative laminate panel in final form. The pressure pad 215 preferably comprises a compressible fabric prepared from copper, silicone, or NOMEX®, or a combination of the preceding. NOMEX® is an aramid fabric available from DuPont de Nemours, E.I. & Company.

[0034] A flexible metal plate 220, such as a flexible aluminum plate of approximately 20-140 mm (508 to 3556 microns), is then placed on top of the pressure pad 215. Although the metal plate 220 is flexible, the metal plate 220 is preferably a substantially smooth, flat surface. A paper layer 225 (e.g., acrylic paper) is also then placed against

the flexible metal plate 220. Preferably, the paper layer 225 comprises an adhesive surface (e.g., acrylic adhesive, not shown) on at least one side. The adhesive surface of the paper 225 is positioned facing away from the flexible metal plate 220, such that the adhesive surface will adhere to the next layer, the extruded sheet 230. As such, the paper layer 225 will removably adhere to the final decorative product during the setting process, and can be peeled away from the decorative laminate panel when the decorative laminate panel is ultimately put to use. The paper layer 225 therefore provides a layer of surface finish to the corresponding extruded sheet 230 (and 240, if appropriate).

[0035] A first laminate sheet 230 is then positioned on top of the paper layer 225. In at least one exemplary implementation of the present invention, the first laminate sheet 230 (as well as the second laminate sheet 240) comprises transparent or translucent extruded copolyesters containing repeating units of terephthalic acid residues (e.g., PETG), ethylene glycol residues, and cyclohexanedimethanol residues.

[0036] The first and second laminate sheets 230 and 240 can also comprise extruded polycarbonate. The term “polycarbonate” refers generally to thermoplastic, aromatic polymers including homopolycarbonates, copolycarbonates, copolyestercarbonates and mixtures thereof having average molecular weights of between approximately 8,000 amu (atomic mass units) and 200,000 amu. Preferably, polycarbonates for use with some implementations the present invention have molecular weights of between approximately 20,000 amu and 80,000 amu, and have an intrinsic viscosity (I.V.) of approximately 0.40 to approximately 1.5 dl/g as measured in methylene chloride at approximately 25° C.

[0037] The first and second laminate sheets 230 and 240 each have a thickness of generally between approximately 0.1 inches and approximately 0.2 inches, depending on the desired thickness of the final decorative laminate panel. For example, a relatively thin decorative laminate panel will comprise a single image layer of two laminate sheets each having a thickness of approximately 0.118-inches. While on the other hand, a thicker decorative laminate panel will comprise a single or double image layer of two or more laminate sheets each having a thickness of approximately 0.177 inches. Additional considerations for choosing thinner or thicker first and second laminate sheets 230 and 240 can depend on the thickness of the embedded objects 235 placed inside.

[0038] Embedded objects 235 can then be positioned against the first laminate sheet 230. For the purposes of this specification and claims, the term “embedded objects” refers to any objects that are intended to be, or have already been, embedded in a decorative laminate panel, such as any organic and inorganic materials. In addition, “embedded objects” comprises any organic or inorganic materials that can be construed as “compressible objects”.

[0039] For the purposes of this specification and claims, organic materials will be understood to comprise any natural or synthetic decorative materials, such as thatch, bamboo, tree or bush branches or stems, willow reed, leaves, beans (e.g., coffee beans), and so forth. The foregoing list, however, is not intended to be exhaustive, but merely illustrative of the type of materials that can be used in accordance with the present invention, and that otherwise would not be suitable for use in conventional thermosetting processes. Similarly, inorganic materials, by contrast, can comprise any natural or synthetic items, such as rock, glass, other types of minerals, and so forth.

Such inorganic items will ordinarily be crushed so that the final decorative product does not exceed a desired thickness, or thinness, and to make sure the final panel has a smooth, uniform surface (e.g., viewable surfaces 105, 115, 125). The thickness of either organic or inorganic materials will be between approximately 0.05 and approximately 0.5 inches.

[0040] In any case, embedded objects 235 are prepared to ensure no quality loss in the decorative laminate panel surface, or to the embedded objects 235 themselves. For example, a manufacturer will generally ensure that the randomly-placed objects do not form completed shapes, such as, for example, a completed circle or square. Completed shapes would otherwise trap air in the decorative laminate panel, and can result in surface imperfections, sometimes referred to as “lakes”, on the surface of the decorative laminate panel surface (e.g., 105, 115, 125). In some cases, the lake can appear as a slightly shinier portion of the decorative laminate surface compared with the remainder of the surface. Furthermore, the manufacturer can make sure the embedded objects 235 have been dried sufficiently, to prevent complications due to moisture exiting the object 235. As well, the manufacture can also apply a fungicide or bacterial agent to the embedded objects 235 to remove growths that could potentially damage the embedded objects 235 in the final product.

[0041] With the embedded objects 235 positioned appropriately, the manufacturer can then position a second laminate sheet 240 against the embedded objects 235, such that the embedded objects 235 are surrounded on two sides by opposing laminate sheets 230 and 240. As shown in Figures 2A and 2B, the assembly 200 forms a single image layer. If the manufacturer intends only to create a single image layer, then the preceding layers of paper 225, metal sheet 220, and so forth are added to the opposing side of the second

laminate sheet 240 prior to sending the assembly 200 through a stationary press. On the other hand, if the manufacturer desires to create multiple image layers, preceding steps are merely repeated iteratively as desired into a larger stack. Hence, a double image layer will comprise two sets of first and second laminate sheets 230 and 240 stacked together, a triple-image layer will comprise three sets of first and second laminate sheets 230 and 240 stacked together, and so on.

[0042] Figure 3A illustrates a chart of primary processing steps and corresponding pressure and temperature ranges for implementing a process for forming a decorative laminate panel. The temperatures and pressures illustrated in Figure 3A are specific to extruded PETG sheets, and extruded copolyester sheets having similar properties. One reason PETG and related materials are particularly useful with the present invention is that they have a melting point that renders them particularly suitable for embedding materials that would otherwise collapse at conventional pressures, or that otherwise be destroyed at conventional temperatures.

[0043] In addition, PETG panels are resilient, resistant to cracking and other stresses that would damage other materials. By contrast, while polycarbonate is also a similarly strong material, extruded polycarbonate has a higher melting point than extruded PETG. As such, embedded materials 235 for use with extruded polycarbonate would need to be chosen that have melting points higher than the appropriate range for extruded polycarbonate, and that are of sufficient integrity as not to be destroyed in the thermosetting process. Thus, though there may be some variance in choosing embedded materials to fit the properties of a given extruded sheet material, the processes in accordance with the present invention can be applied to a broad range of extruded and embedded materials.

[0044] By way of explanation and not of limitation, PETG and related copolyesters include a polyethylene terephthalate polyester modified with 2 mole % to 99 mole % of cyclohexanedimethanol repeat unit. The cyclohexanedimethanol may be either the 1,4- or 1,3-isomer and may be either in the cis- or trans- form or a mixture of the isomers. The copolyester may be semi-crystalline or amorphous, preferably amorphous.

[0045] The copolyester contains repeat units from a dicarboxylic acid and a diol, based on 100 mole % dicarboxylic acid and 100 mole % diol. The dicarboxylic acid component contains at least 80 mole % of terephthalic acid or dimethylterephthalate. The copolyester may optionally be modified with up to 20 mole % of one or more different dicarboxylic acids other than terephthalic acid or dimethylterephthalate such that the total dicarboxylic acid content is equal to 100 mole %. Examples of other dicarboxylic acids which may be used with terephthalic acid include phthalic acid, isophthalic acid, 1,4-, 1,5-, 2,6-, and 2,7-naphthalenedicarboxylic acid, 1,3-, 1,4-cyclohexanedicarboxylic acid, cyclohexanediacetic acid, oxydibenzoic acid, 4,4-biphenyldicarboxylic acid, succinic acid, glutaric acid, adipic acid, azelaic acid, sebacic acid, suberic acid, pimelic acid, and 1,12-dodecanedioic acid. The copolyester may be prepared from one or more of the above dicarboxylic acids.

[0046] It should be understood that use of the corresponding acid anhydrides, esters, and acid chlorides of these acids is included in the term "dicarboxylic acid".

[0047] The diol component contains repeat units from 98 to 1 mole % ethylene glycol and 2 to 99 mole % 1,4-cyclohexanedimethanol and/or 1,3-cyclohexanedimethanol. The cyclohexanedimethanol may be present as the cis or trans isomer or mixtures thereof. In addition, the diol component can optionally be modified with up to 20 mole % of one or more different diols other than ethylene glycol and cyclohexanedimethanol such that the

total diol content is equal to 100 mole %. The additional diols include cycloaliphatic diols having 6 to 16 carbon atoms and aliphatic diols having 3 to 16 carbon atoms.

[0048] Examples of diols which may be used with ethylene glycol and cyclohexanedimethanol include diethylene glycol, triethylene glycol, propane-1,3-diol, butane-1,4-diol, pentane-1,5-diol, hexane-1,6-diol, 3-methylpentanediol-(2,4), 2-methylpentanediol-(1,4), 2,2,4-trimethylpentane-diol-(1,3), 2-ethylhexanediol-(1,3), 2,2-diethylpropane-diol-(1,3), hexanediol-(1,3), 1,4-di-(hydroxyethoxy)-benzene, 2,2-bis-(4-hydroxycyclohexyl)-propane, 2,4-dihydroxy-1,1,3,3-tetramethyl-cyclobutane, 2,2-bis-(3-hydroxyethoxyphenyl)-propane, and 2,2-bis-(4-hydroxypropoxyphenyl)-propane. The copolyester may be prepared from one or more of the above diols. The copolyesters may also be modified with polyethylene glycols or polytetramethylene glycols to enhance elastomeric behavior.

[0049] As used herein, the related copolyester also has an inherent viscosity of 0.5 to 1.2 dL/g. Preferably, the copolyester has an inherent viscosity of 0.6 to 0.9 dL/g as measured at 25° F using 0.50 grams of polymer per 100 ml of a solvent consisting of 60% by weight phenol and 40% by weight tetrachloroethane. It is especially preferred that the copolyester be prepared from or derived from repeating units consisting of terephthalic acid units, ethylene glycol units and 1,4-cyclohexanedimethanol units.

[0050] Referring again to the figures, steps 310, 320, 330, and 340 are described with respect to the illustrations of Figures 3B and 3C. In particular, Figure 3B illustrates a sequence of physical changes in a single-layered laminate assembly when the single-layered laminate assembly undergoes process steps 310, 320, 330, and 340. Similarly, Figure 3C illustrates a sequence of physical changes in a multi-layered laminate

assembly when the two-layered laminate assembly undergoes process steps 310, 320, 330, and 340.

[0051] As previously indicated, a manufacturer places the laminate assembly 200 in a thermosetting environment (e.g., stationary press) so that the laminate assembly 200 can undergo a series of pressure and temperature changes. In a first step 310, for example, a manufacturer can apply between approximately 5 to 10 psi of pressure on the laminate assembly 200, and raise the temperature from between approximately 70° F to approximately 180° F. As illustrated in Figures 3B and 3C, the first and second laminate sheets 230 and 240 (as well as sheets 250 and 260 for multiple layers, etc.) begin to soften around the embedded materials 235. In addition, air between the laminate sheets preferably begins to evacuate as the laminate sheets compress together during step 310. At this temperature and pressure, however, the embedded materials 235 are unlikely to be enveloped entirely by either of the first or second laminate sheets 230 and 240.

[0052] The manufacturer can then perform a second step 320 of raising the pressure to between approximately 30-40 psi, and raising the temperature between approximately 180° F and approximately 230° F. As illustrated in Figures 3B and 3C, therefore, the first and second laminate sheets 230, and 240 (as well as sheets 250 and 250 for multiple layers, etc.) soften sufficiently that the embedded materials 235 are completely enveloped by the corresponding opposing first and second laminate sheets. Preferably, air between the laminate sheets has then completely evacuated from the laminate assembly 230, such that the laminate assembly 200 becomes substantially free of air.

[0053] The manufacturer then finalizes the decorative laminate panel in steps 330 and 340, whereby the laminate assembly 200 is pressed into final form 330, and then cooled

340. For example, in step 330, the manufacturer can raise the pressure to approximately 92 psi, and raise the temperature to between approximately 230° F and approximately 240° F. The manufacturer holds this temperature and pressure for a time of up to approximately 5 minutes or less, until the assembly 200 is pressed into final form. Thereafter, the manufacturer cools the laminate assembly 200 to a temperature approaching 70° F, and removes the final, hardened decorative laminate panel 100 (or 120) from the stationary press, and from the metal trays (e.g., 210, 220) of the laminate assembly 200. Cross sectional views 107 and 127 of the corresponding decorative laminate panel 100 and 120 show that the embedded materials 235 have been substantially preserved such that they have not been significantly crushed in the laminating process.

[0054] Of course, the manufacturer can also adjust the foregoing temperatures and pressures, as described herein, in order to suit the melting points of other extruded materials. With respect to extruded polycarbonate, for example, the manufacturer may adjust the temperatures described for the table in Figure 3A by adding approximately 120° F to many of the higher-end temperatures.

[0055] As such, step 310 would comprise implementing a pressure of approximately 5-10 psi on an extruded polycarbonate assembly, and raising the temperature from approximately 70-80° F to approximately 300° F. Furthermore, step 320 would comprise implementing a pressure of approximately 30-40 psi on the extruded polycarbonate assembly, and raising the temperature from approximately 300° F to 350° F. Step 330 would comprise implementing a pressure of approximately 92 psi, and raising the temperature from approximately 350° F to approximately 360° F. And step 340 would comprise holding a pressure of approximately 92 psi on the polycarbonate

assembly, and reducing the temperature from 360° F to as low as approximately 70°-80° F. Of note, the low end values of 70°-80° are typically lowest approximations of a final or initial cooling value, and may be higher or lower as appropriate without affecting the quality of the decorative laminate product.

[0056] Accordingly, one will appreciate that the foregoing pressure and temperature values for extruded PETG sheets and extruded polycarbonate sheets are merely exemplary implementations of the invention. Even further, the previously described temperatures are each, nevertheless, only an approximate value existing within a range of \pm approximately 15°-20° F. As such, a manufacturer need not ensure that the temperatures and pressures of a given process reach the previously described pressures and temperatures exactly. In particular, the manufacturer need only ensure that the temperatures and pressures of a given process are in a suitable range for softening and melting the respective extruded sheet materials about the corresponding embedded objects 235.

[0057] In any case, and regardless of the material and process values implemented, the manufacturer then reviews the decorative laminate panel 100, 120 and observes the product for trapped air, which can be evidenced by surface lakes. The manufacturer, however, can easily remove the lakes by sending the now-hardened, decorative product back through the stationary press one or two more times, as necessary. As such, there is relatively little need to discard errant decorative laminate panels, which thereby enhances the production efficiency for the decorative laminate panels. Thus, the foregoing apparatus and processes in accordance with the present invention allow for a large volume of decorative laminate panels to be created with a relatively low error rate.

[0058] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

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